PHD TOPIC 2021

Multicriteria optimisation of functional properties of spray-dried dairy powders (OptiLait)

Workplace: Laboratoire d'ingénierie des biomolécules (LIBio) - 2, avenue de la Forêt de Haye - BP 20163 - 54505 VANDŒUVRE-LES-NANCY - France.

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Doctoral school: #607 - Sciences et Ingénierie des Ressources Naturelles (SIReNa) - University of Lorraine.

Funding: Doctoral contract of the French Ministry of Higher Education, Research and Innovation.

Beginning of the PhD: 04/10/21.

Application deadline: 14/07/21.

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Thank you for sending a curriculum vitae and a motivation letter for your application.

Scientific fields: process engineering - food physicochemistry - divided solids

Keywords: powders - dairy - reconstitution - flowing - gelation - encapsulation - spray-drying - membrane filtration - evapoconcentration - modelling - multicriteria optimisation.

PhD mention: food and biotechnology engineering.

Applicant profile:

- The applicant must have skills and theoretical knowledges of Master's degree in **process engineering** and **modelling**. This will allow him/her to manage **multicriteria design of experiments, empirical modelling** of the links between manufacturing conditions and functional properties of spray-dried dairy powders, and the **multicriteria optimisation** approach which will be developed in collaboration with the LRGP (University of Loraine).
- The applicant should have skills and theoretical knowledges in **food science** and in **milk physicochemistry**. A training in these fields would be beneficial.
- The **English level** of the applicant should allow him/her to present and discuss his/her results with other researchers and write scientific texts: a **B2 level** is required.
- The applicant should be very interested in the **scientific research approach** and **interdisciplinary studies**. He/she should have great skills for **teamwork** and be able to **summarise information** and **communicate**. Besides his/her natural **curiosity** for scientific enigma, he/she should be **autonomous, meticulous,** and **invest in his/her work**.

PhD topic:

The upholding of the quality of dairy powders is nowadays a great challenge, as their **functionalities** (texturing ability, nutritional quality, etc.) are **interesting for many food products**. However, **good flowability and reconstitutability,** among other functional properties, are required for their use in manufacturing processes. Dairy powder functionalities are particularly **dependent from their chemical composition**, especially their **protein composition**. Besides their functional properties allowing to use them in a great variety of applications as functional ingredients, dairy powder also constitute innovative **encapsulation matrices** for the **preservation of bioactive ingredients,** such as probiotic bacteria or antioxidant biomolecules. Dairy powders being mainly produced by **spray-drying,** the understanding of the impact of spray-drying process conditions on the functional properties of dairy powders is an important research topic that is intricate, owing to the **numerous involved biochemical mechanisms**. To address these challenges, it is necessary to study the influence of **manufacturing process conditions** on the **bulk and surface physicochemical properties** of dairy powders and the link between physicochemistry, **structure**, and **functionalities** of dairy powders.

The **main objective** of the OptiLait doctoral project is to develop a **numerical tool** of choice of **manufacturing process conditions of dairy powders** (concentrate formulation and spray-drying) allowing to simultaneously obtain **good functional properties** in terms of flowability, reconstitutability, preservation ability, gelation ability, and bioactive ingredients protection.

The overall approach of the Optilait doctoral project is built in two main phases.

- The **experimental phase** will be dedicated to **produce skim milk and dairy protein powders in various manufacturing process conditions** and **characterize their physicochemical and functional properties**.
- Then, the **numerical phase** will first deal with the **identification of the process parameters having the most influence** on all dairy powder functionalities by using **principal component analysis** and/or **partial least squares** modeling approach. After that, **empirical models relating manufacturing process conditions to functional properties of spray-dried dairy powders** will be developed in the basis of **multicriteria design of experiments** and/or **dimensional analysis**. These empirical models will allow **predicting the functionalitie**s of dairy powders in the investigated variation ranges of process conditions and will constitute the basis of the **multicriteria optimisation** approach. In the latter, a **genetico-evolutionary algorithm will** be developed to explore the whole variation domain of dairy powder manufacturing process conditions and determine the **Pareto-optimal zone,** i.e. all the **process conditions** permitting to obtain the **best compromises** between dairy powder functionalities. Then, **requirement specifications** based on the usual practices of dairy industrials in matter of spray-drying will be translated in a **choice algorithm** permitting to **sort the process conditions** of the Pareto-optimal zone. Last, the **constraints associated with bioactive ingredients encapsulation** will be taken into account to **choose optimal manufacturing process conditions** for this peculiar application of spray-dried dairy powders.

Trials of production of dairy powders encapsulating bioactive ingredients (probiotic bateria, enzymes, and antioxidant biomolecules) will be performed in these optimal process conditions and the physicochemistry and functionalities of spray-dried dairy powders will be determined to check the efficiency of the multicriteria optimization approach on these **proofs of concept.**

The originality of the OptiLait doctoral project lies on one hand on the consideration of all industrial steps of milk powdering in the experimental set-up and on the other hand on the development of a multicriteria optimization approach permitting to identify the manufacturing process conditions of spray-dried dairy powders allowing the best compromises between powder functionalities.

Consistency with LIBio's research theme:

The OptiLait doctoral project completely enters into the LIBio's research theme, which deals with the **rational conception of bio-based matrices and vectors suitable for the stabilization of various bioactive compounds and food ingredients with targeted functionalities.** In the LIBio laboratory, numerous molecular architectures are developed by taking into account the influence of the nature of employed bio-based macromolecules (especially, dairy proteins) and the structuration conditions (environment, bioprocess, formulation) on the structure and functionalities of developed systems. The **modification of the formulation and the manufacturing process of dairy powders** allows **controlling their structuration** and thus **their use properties and their ability to transport bioactive compounds.**

The OptiLait doctoral project will permit to strengthen the LIBio skills in the dairy field, which constituted one of the main research project of the LIBio and one of the priority of the Grand Est region.